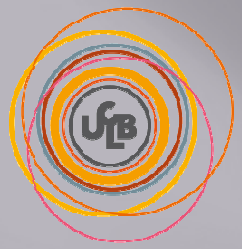


Belarussian
State University

ADVANCES IN ANODIC ALUMINA

(PERSPECTIVE MULTIPURPOSE MATERIAL)

Presented by P. Nedelec

Collaboration

K Delendik, G Drobychev, P Nedelec, D Sillou, O Voitik, …

+

Background of the "use" of Anodic Alumina Oxyde

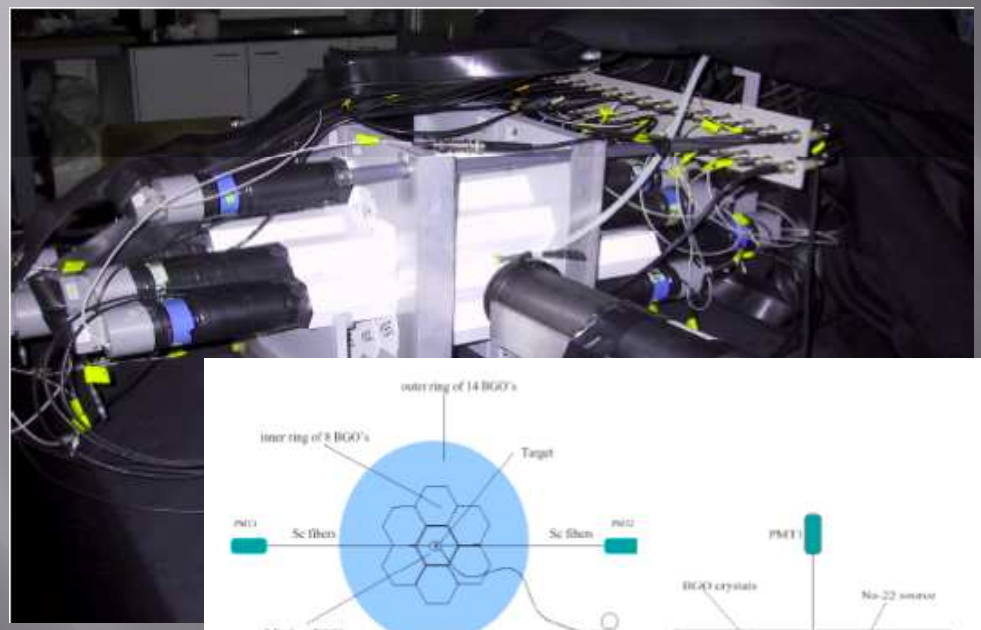
- Fundamental physics with oPs
  - Exotic decays of oPs
  - Search for Mirror World in oPs disintegrations
- Need positron source/beam
  - Design a continuous beam
  - Make a pulsed beam
- See interest for material physics (LMPOS)
  - Make a PALS setup for polymer studies
  - Add DBS setup
- Think of AAO for
  - chip-MPC
  - oPs production
- Back on fundamental physics
  - Anti-matter Free Fall (AEGIS)

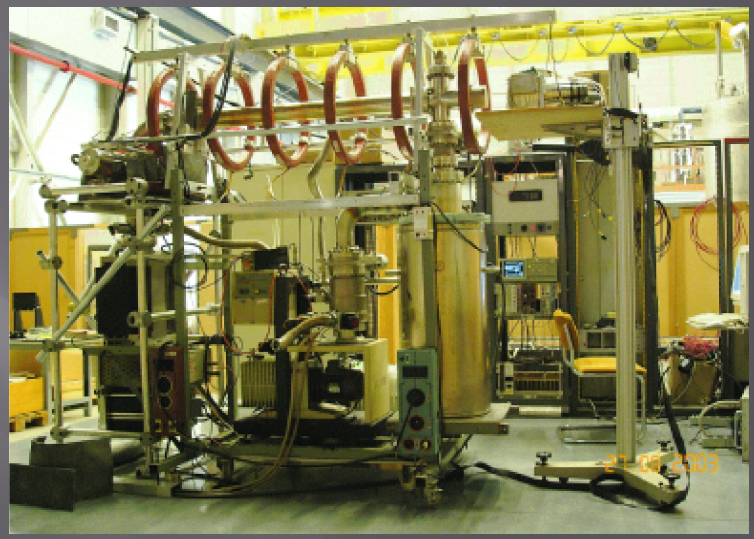
Exotic decay of positronium

Search of an exotic decay channel of oPs.

$$e^+e^-(o-Ps) \rightarrow \gamma + (X_1 + X_2)$$ → Two weak interacting massive particles

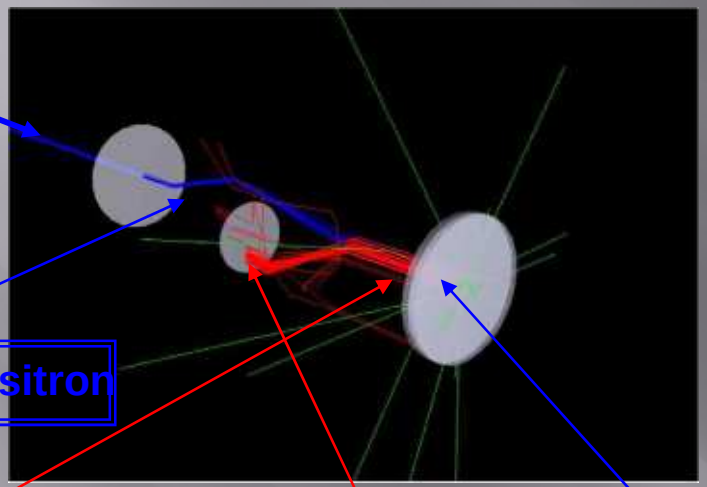
Phys.Lett. B542: 29-34, 2002)





Continuous and pulsed beam (CERN)

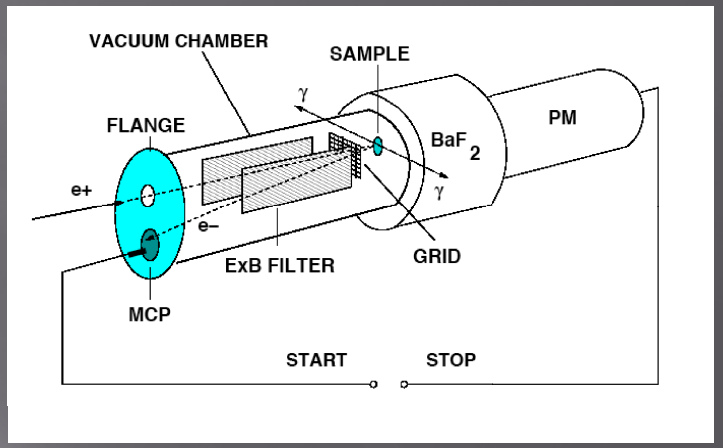
Secondary Electrons

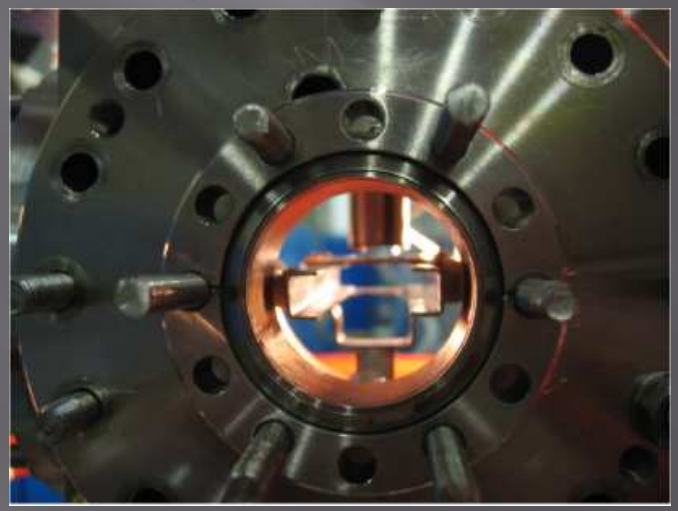


-Incident positron

Secondary electron

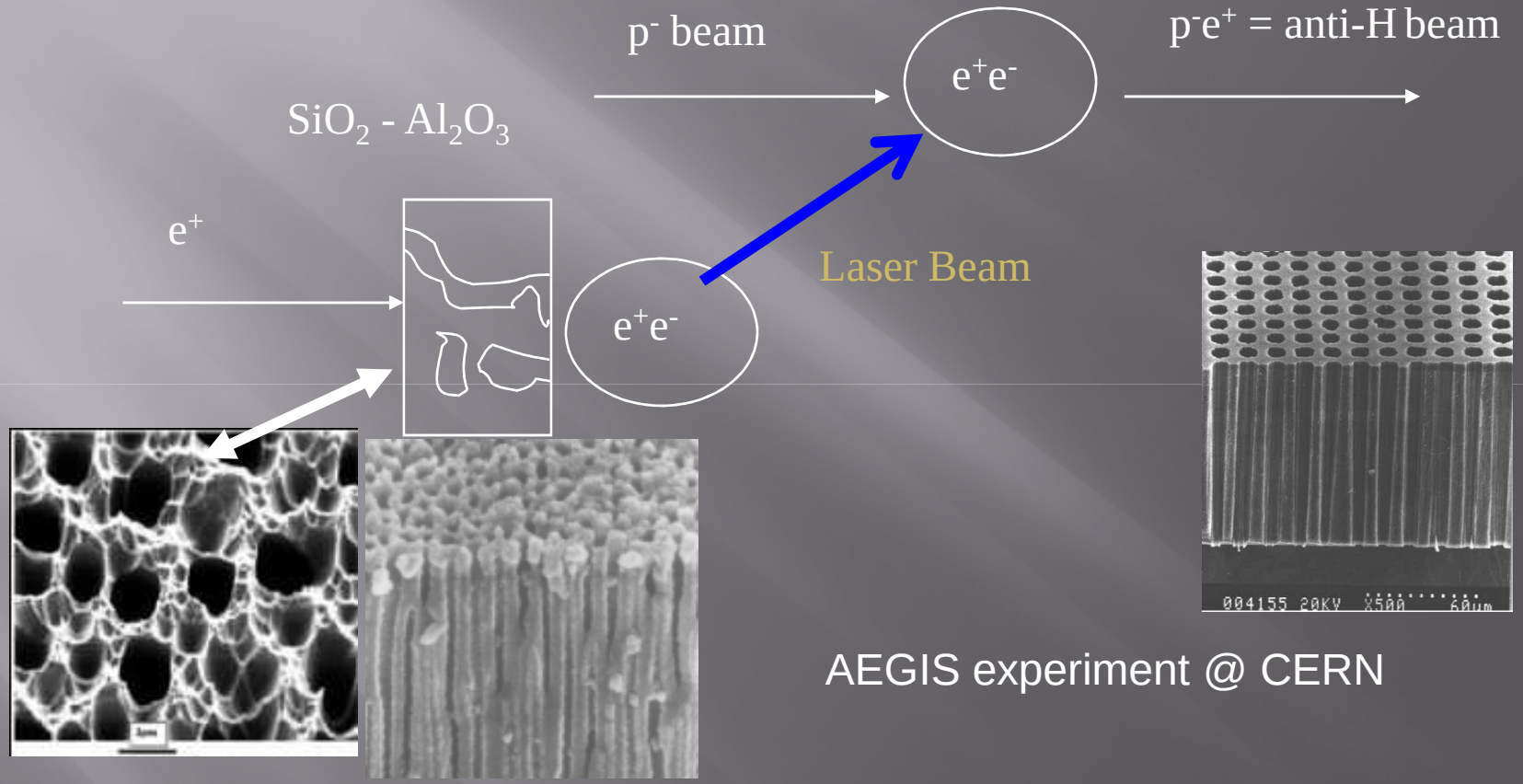
MCP





Anti hydrogen beam

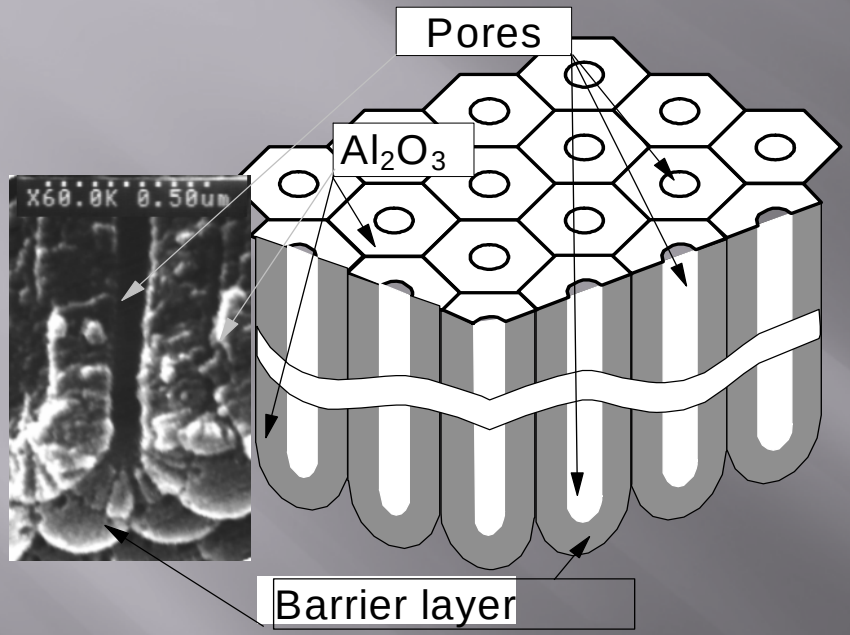
Development of micro-channel plates on a basis of aluminum oxide LAPP EXP-05-2005

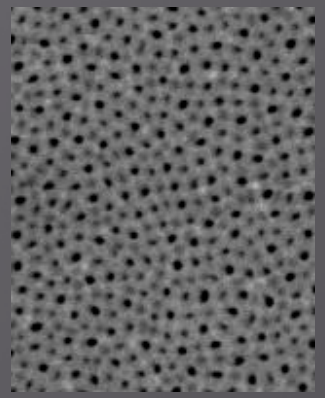


AEGIS experiment @ CERN

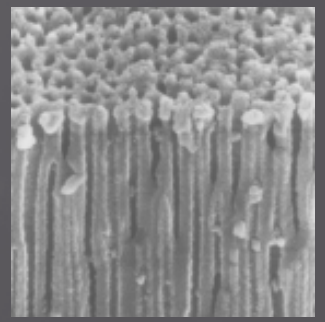
Development of micro-channel plates on a basis of aluminium oxide. G. Drobychev, A. Barysevich, K. Delendik, A. Karneyeu, P. Nédélec, D. Sillou, OlgaVoitik. Presented at Beaune05 & NDIP08 Conference. NIM A 567 (2006) 290–293.

Anodic Aluminium Oxide (AAO):

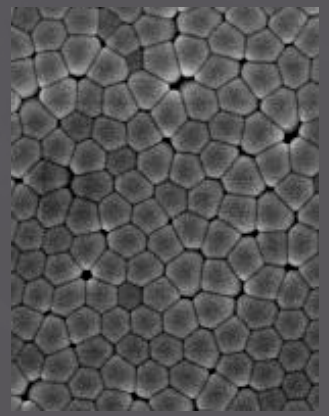




Porous side



Cross section



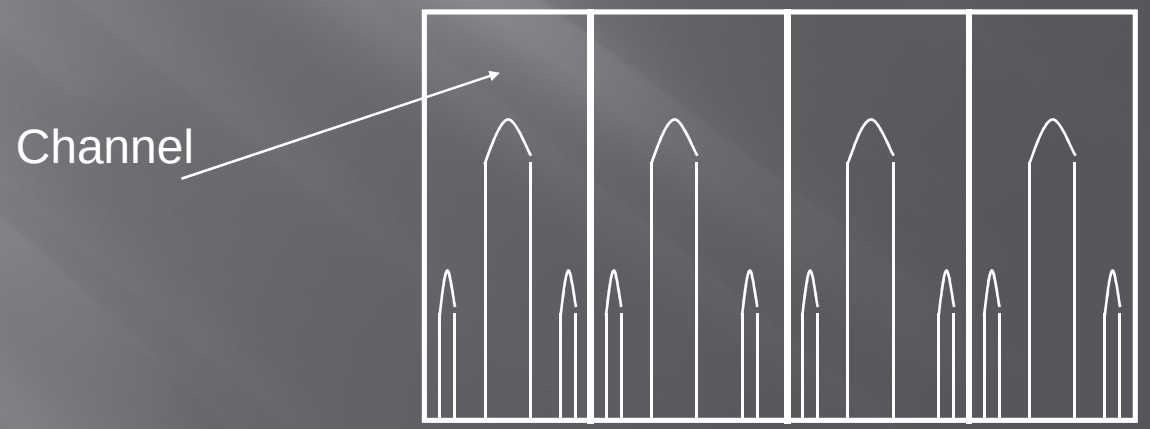
Barrier layer
attached to aluminium substrate

Anodic alumina as a potential material for positronium production

- Thickness can be from several 10 μm to 300 μm
- Diameter of channels are precisely controlled in the region from 10 to 250 nm (natural porosity) and >5 μm with use of etching technology.
- Regular porous structure with possibility to remove barrier layer (open channels)
- Total surface is up to 5*5 cm and 7*7 cm with special production technology
- Surface of channels to total surface ratio up to 50%

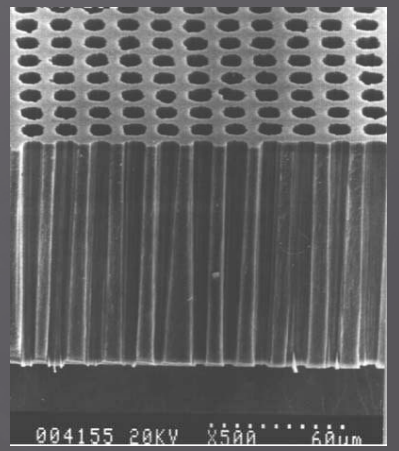
Anodic alumina for positronium production – future:

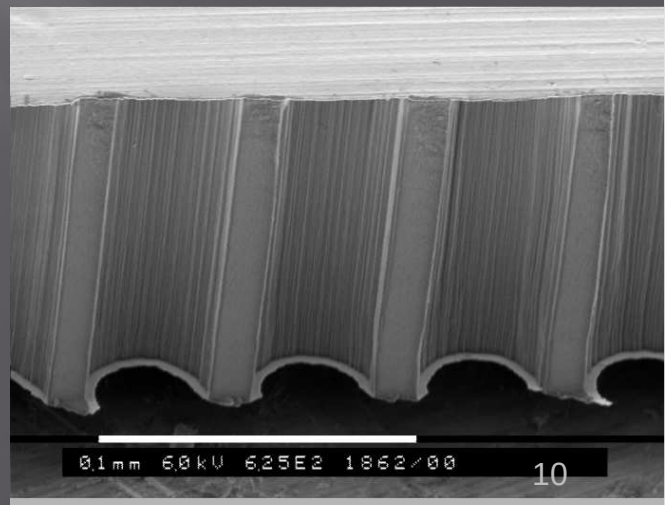
- To test AAO samples at high and low temperature with radioactive source at LMOPS/Sofia.
- To test more samples at the beam facility (time of flight).
- To test dendroid structure:



Anodic alumina as a potential material for MCP production

- Effective secondary electron emitter.
- Possible to produce structure of necessary geometry.
- Surface of plate is up to 50*50 mm.
- Thickness is from several up to 250 μm.
- Channels diameter from 10 to 250 nm (natural porosity).
- The technology exist to produce samples with any required channels diameter starting from about 5 μm.





Problem:

- Natural AAO MCP have too big electric resistance to be a good MCP!

AAO is a dielectric:

- Electric resistance of the AAO is more than 10 GOhm at the plate thickness of about 100 μm.
- As a consequence, currents in the plate is smaller than 200-300 nA at the 1-3 kV tension – impossible to measure.
- To create MCP on a basis of AAO, first, it is necessary to increase its electric conductivity.
- The conductivity of AAO MCP must be less than hundreds MOhm (in case of 3 kV working HV)

First method:

- To increase a bulk conductivity of a material by
  - Anodizing of the alloy of aluminium with other metals
  - Incorporation of the metals ions into AAO during an electrochemical process of aluminium oxidation.

Anodizing of the alloy:

- **A series of experiments were made. Samples were anodised in the sulfuric acid**

Alloy	Mg, %	Si, %	Mn, %
AL-8	9,3-10	-	-
AMG-3	4,5-5,5	0,8-1,3	0,1-0,4

- **No difference in resistance was found**

INCORPORATING METAL IONS DURING OXIDATION PROCESS:

- **Metal containing chemicals are introduced into electrolytic solution;**
- **An alternative voltage of special shape is used during anodizing;**
- **AAO growths during anodic half-cycle and discharge of the metals ions occurs near the bottom of the porous during a cathodic half-cycle;**
- **Quantity of deposited metal is determined by electric current parameters.**
- **The following metals were tested:**
  Zn, Sn, Ni, Mg, Al, Cu, W, Ta, Mo, Pb.

Results:

- Till now we managed to incorporate Pb only.
- The methods allow to control precisely a quantity of incorporated metal.
- There is a homogeneous distribution of the metals in the AAO.
- No significant change in the electric conductivity was measured.
- Metals incorporated into AAO must be activated to influence the conducting properties by a partial reduction of metals oxides in the near-surface areas of the MCP's channels walls.
- We plan to use an annealing of the samples in the hydrogen atmosphere or in vacuum.
- We work now for the optimization of the thermal treatment parameters.

Second method:

- **To deposit conductive layers of metals oxides onto the inner channels surfaces by different methods. In particular, vacuum deposition of metals with consequent oxidation and *deposit of metal organic compounds with consequent annealing* (*under research*).**
- **Use of nickel and magnesium oxides were studied until today.**

Results:

- Up to date, good results were achieved with MCP with nickel oxide deposit.
- Plates, treated by this technology have electric resistance from 40 Mohm/mm to Gohm/mm.
- A resistance can be controlled during technological process.

Anodic alumina as a potential material for MCP production – plans

- **To complete systematic studies of the AAO resistance reduction methods in order to optimize technology.**
- **To test amplification of the AAO MCP with increased conductivity and channels enlarged by etching.**

Anodic alumina as a potential material for filtering

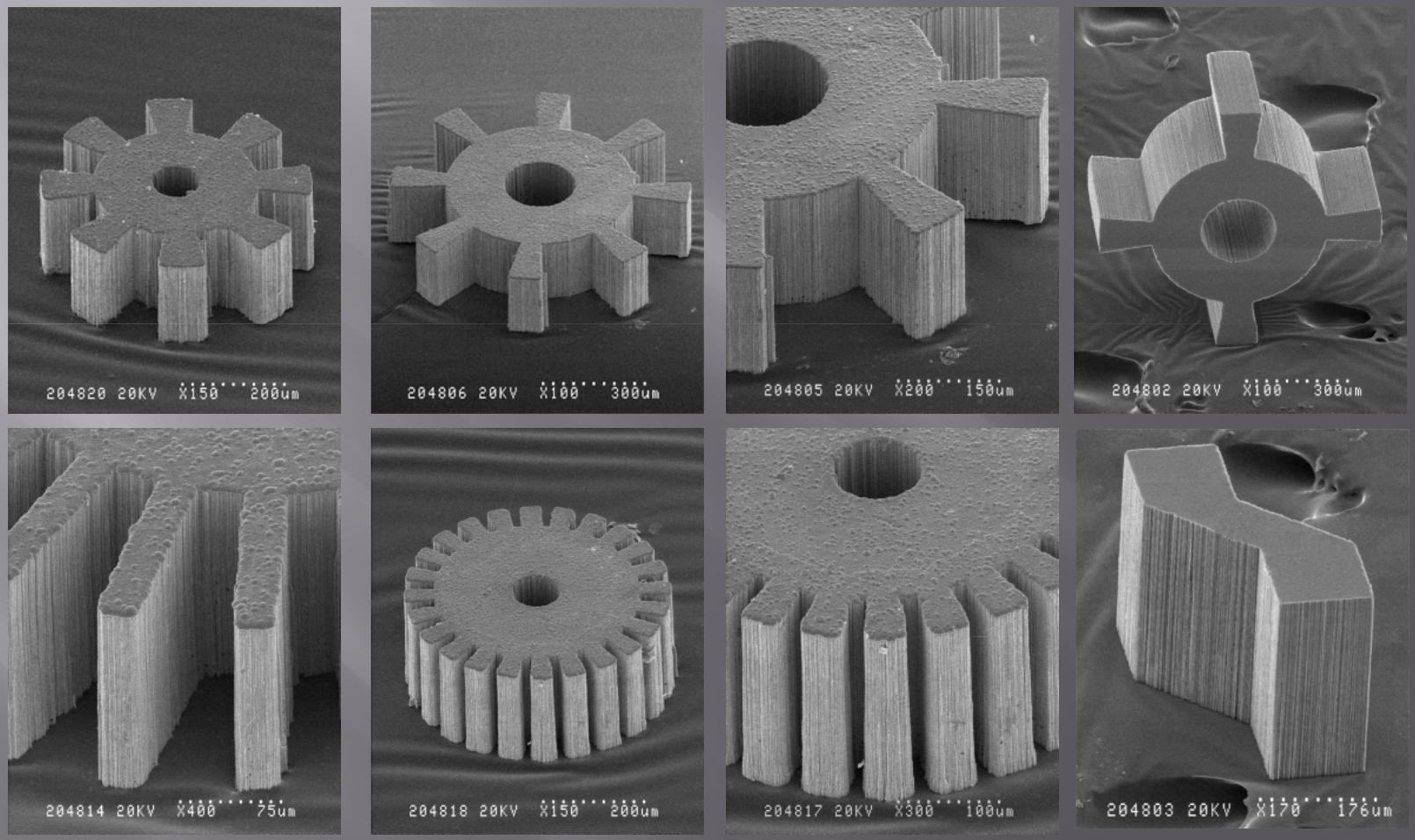
Sizes of some dangerous objects:

- **Staphylococcus - 1000 nm**
- **Grippe virus – 50 - 100 nm**
- **Smoke micro-particles – 10 – 50 nm**

Anodic alumina as a potential material for catalyzing

- **Free surface of natural structure is more than 10^3 m^2/g (standard catalytic powders are about 300 m^2/g)**
- **After annealing a secondary porosity can be created, which increase surface significantly (10^4 – 10^5 m^2/g)**
- **Technology to insert nano-disperced media into secondary porosity is developed**

AAO micro structures



Conclusion

- Al2O3 is useful in a wide range of applications
- oPs production
- C-MCP bulk material (work to be done still)
  - Make it work
  - Large size, Low cost,...
- Filtering (H2,...)
- Catalizing (annealing structure)
- Micro-mechanics
- ...